

## C3246 Log Data Report

### **Borehole Information:**

| Borehole:     | C3246           |                         | Site:                      | 216-B-12 Crib    |            |
|---------------|-----------------|-------------------------|----------------------------|------------------|------------|
| Coordinates ( | WA State Plane) | GWL (ft) <sup>1</sup> : | 305.08                     | GWL Date:        | 6/19/2003  |
| North         | East            | Drill Date              | TOC <sup>2</sup> Elevation | Total Depth (ft) | Type       |
| 136,589.69 m  | 573,128.61 m    | June 2003               | 215.01                     | 308              | Cable Tool |

### **Casing Information:**

| Casing Type               | Stickup (ft) | Outer<br>Diameter<br>(in.) | Inside<br>Diameter<br>(in.) | Thickness<br>(in.) | Top<br>(ft) | Bottom<br>(ft) |
|---------------------------|--------------|----------------------------|-----------------------------|--------------------|-------------|----------------|
| Threaded Steel (06/04/03) | 0.5          | 10 11/16                   | 9 3/4                       | 15/32              | +0.5        | 111            |
| Threaded steel (06/09/03) | 1.1          | 9.0                        | 8.0                         | 1/2                | +1.1        | 149            |
| Threaded steel (06/18/03) | 1.1          | 6 5/8                      | 5 1/2                       | 9/16               | +1.1        | 303            |

The logging engineer measured the outside casing diameter with a caliper. Inside casing diameter and the caliper were measured using a steel tape; measurements were rounded to the nearest 1/16 in. Casing thickness was calculated. The driller supplied casing depth. The stickup was measured using a steel tape.

### **Borehole Notes:**

Zero reference is the ground surface. This borehole was logged through the drill pipe in stages through single strings of casing. There is approximately 6 in. of crushed gravel at the surface. Borehole coordinates and elevation were provided by the project lead. The driller reported that drilling stopped when the groundwater's capillary fringe was reached. Wet mud was sticking to the e-tape's sonde when the groundwater level was measured.

### **Logging Equipment Information:**

| Logging System:   | Gamma 2E |                        | <b>Type:</b> 70% HPGe (34TP40587A) |
|-------------------|----------|------------------------|------------------------------------|
| Calibration Date: | 03/2003  | Calibration Reference: | GJO-2003-430-TAC                   |
|                   |          | Logging Procedure:     | MAC-HGLP 1.6.5, Rev. 0             |

| Logging System:   | Gamma 1C |                        | Type:    | High Rate Detector (39-A314) |
|-------------------|----------|------------------------|----------|------------------------------|
| Calibration Date: | 02/2002  | Calibration Reference: | GJO-2002 | 2-309-TAR                    |
|                   |          | Logging Procedure:     | MAC-HGI  | LP 1.6.5, Rev. 0             |

| Logging System:   | Gamma 2F |                        | <b>Type:</b> Moisture (H380932510) |
|-------------------|----------|------------------------|------------------------------------|
| Calibration Date: | 10/2002  | Calibration Reference: | GJO-2002-387-TAC                   |
|                   |          | Logging Procedure:     | MAC-HGLP 1.6.5, Rev. 0             |

## Spectral Gamma Logging System (SGLS) Log Run Information:

| Log Run                     | 1  | 2   | 3                        | 4/Repeat        | 5   |
|-----------------------------|--|---|--------------------------|-----------------|---|
| Date                        | 6/5/03   | 6/5/03  | 6/5/03                   | 6/5/03          | 6/9/03  |
| Logging Engineer            | Spatz  | Spatz   | Spatz                    | Spatz           | Spatz   |
| Start Depth (ft)            | 0.0  | 31.0  | 70.0                     | 30.0            | 147.0   |
| Finish Depth (ft)           | 32.0   | 70.0  | 110.0                    | 19.0            | 109.0   |
| Count Time (sec)            | 100  | 15  | 100                      | 100             | 100   |
| Live/Real                   | R  | R   | R                        | R               | R   |
| Shield (Y/N)                | N  | N   | N                        | N               | N   |
| MSA Interval (ft)           | 1.0  | 1.0   | 1.0                      | 1.0             | 1.0   |
| ft/min                      | N/A <sup>3</sup>   | N/A   | N/A                      | N/A             | N/A   |
| Pre-Verification            | BE036CAB   | BE036CAB  | BE036CAB                 | BE036CAB        | BE037CAB  |
| Start File                  | BE036000   | BE036033  | BE036073                 | BE036114        | BE037000  |
| Finish File                 | BE036032   | BE036072  | BE036113                 | BE036125        | BE037038  |
| Post-Verification           | BE036CAA   | BE036CAA  | BE036CAA                 | BE036CAA        | BE037CAA  |
| Depth Return<br>Error (in.) | N/A  | N/A   | N/A                      | 0               | N/A   |
| Comments                    | File -028 was<br>repeated see<br>file -116. No<br>fine-gain<br>adjustment. | High-rate zone<br>delineation.<br>No fine-gain<br>adjustment. | No fine-gain adjustment. | Repeat section. | Fine-gain<br>adjustment<br>made after<br>file -018. |

| Log Run                     | 6/Repeat        | 7            | 8/Repeat    |  |
|-----------------------------|-----------------|--------------|-------------|--|
| Date                        | 6/9/03          | 6/19/03      | 6/19/03     |  |
| Logging Engineer            | Spatz           | Spatz        | Spatz       |  |
| Start Depth (ft)            | 115.0           | 305.0        | 166.0       |  |
| Finish Depth (ft)           | 109.0           | 146.0        | 150.0       |  |
| Count Time (sec)            | 100             | 100          | 100         |  |
| Live/Real                   | R               | R            | R           |  |
| Shield (Y/N)                | N               | N            | N           |  |
| MSA Interval (ft)           | 1.0             | 1.0          | 1.0         |  |
| ft/min                      | N/A             | N/A          | N/A         |  |
| Pre-Verification            | BE037CAB        | BE044CAB     | BE044CAB    |  |
| Start File                  | BE037039        | BE044000     | BE044160    |  |
| Finish File                 | BE037045        | BE044159     | BE044176    |  |
| Post-Verification           | BE037CAA        | BE044CAA     | BE044CAA    |  |
| Depth Return<br>Error (in.) | 0               | N/A          | +1          |  |
| Comments                    | Fine-gain       | No fine-gain | Repeat      |  |
|                             | adjustment      | adjustment.  | section. No |  |
|                             | made after file |              | fine-gain   |  |
|                             | -041.           |              | adjustment. |  |

### High Rate Logging System (HRLS) Log Run Information:

| Log Run             | 1      | 2      | 3      | 4      | 5/Repeat |
|---------------------|--------|--------|--------|--------|----------|
| Date                | 6/5/03 | 6/5/03 | 6/5/03 | 6/5/03 | 6/5/03   |
| Logging<br>Engineer | Spatz  | Spatz  | Spatz  | Spatz  | Spatz    |
| Start Depth (ft)    | 86.0   | 69.0   | 67.0   | 32.0   | 39.0     |
| Finish Depth (ft)   | 72.0   | 66.0   | 31.0   | 31.0   | 34.0     |
| Count Time (sec)    | 300    | 300    | 100    | 300    | 100      |
| Live/Real           | R      | R      | R      | R      | R        |

| Log Run                     | 1                        | 2                        | 3                        | 4                        | 5/Repeat        |
|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-----------------|
| Shield (Y/N)                | None                     | None                     | None                     | None                     | None            |
| MSA Interval<br>(ft)        | 1.0                      | 1.0                      | 1.0                      | 1.0                      | 1.0             |
| ft/min                      | N/A                      | N/A                      | N/A                      | N/A                      | N/A             |
| Pre-Verification            | AC073CAB                 | AC073CAB                 | AC073CAB                 | AC073CAB                 | AC073CAB        |
| Start File                  | AC073000                 | AC073015                 | AC073019                 | AC073056                 | AC073058        |
| Finish File                 | AC073014                 | AC0730018                | AC073055                 | AC073057                 | AC073063        |
| Post-<br>Verification       | AC073CAA                 | AC073CAA                 | AC073CAA                 | AC073CAA                 | AC073CAA        |
| Depth Return<br>Error (in.) | N/A                      | N/A                      | N/A                      | N/A                      | -1.5            |
| Comments                    | No fine-gain adjustment. | No fine-gain adjustment. | No fine-gain adjustment. | No fine-gain adjustment. | Repeat section. |

### Neutron-Moisture Logging System (NMLS) Log Run Information:

| Log Run                  | 1        | 2/Repeat        | 3        | 4/Repeat        |
|--------------------------|----------|-----------------|----------|-----------------|
| Date                     | 6/4/03   | 6/4/03          | 6/9/03   | 6/9/03          |
| Logging Engineer         | Spatz    | Spatz           | Spatz    | Spatz           |
| Start Depth (ft)         | 0        | 30.0            | 109.0    | 116.0           |
| Finish Depth (ft)        | 110.25   | 42.0            | 147.0    | 122.0           |
| Count Time (sec)         | N/A      | N/A             | N/A      | N/A             |
| Live/Real                | N/A      | N/A             | N/A      | N/A             |
| Shield (Y/N)             | N        | N               | N        | N               |
| MSA Interval (ft)        | N/A      | N/A             | N/A      | N/A             |
| ft/min                   | 1.0      | 1.0             | 1.0      | 1.0             |
| Pre-Verification         | BF061CAB | BF061CAB        | BF062CAB | BF062CAB        |
| Start File               | BF061000 | BF061442        | BF062000 | BF062153        |
| Finish File              | BF061441 | BF061490        | BF062152 | BF062177        |
| Post-Verification        | BF061CAA | BF061CAA        | BF062CAA | BF062CAA        |
| Depth Return Error (in.) | N/A      | 0               | N/A      | -0.5            |
| Comments                 | None     | Repeat section. | None     | Repeat section. |

| Log Run                  | 5        | 6/Repeat        |  |
|--------------------------|----------|-----------------|--|
| Date                     | 6/18/03  | 6/18/03         |  |
| Logging Engineer         | Kos      | Kos             |  |
| Start Depth (ft)         | 146.0    | 290.0           |  |
| Finish Depth (ft)        | 304.75   | 275.0           |  |
| Count Time (sec)         | N/A      | N/A             |  |
| Live/Real                | N/A      | N/A             |  |
| Shield (Y/N)             | N        | N               |  |
| MSA Interval (ft)        | N/A      | N/A             |  |
| ft/min                   | 1.0      | 1.0             |  |
| Pre-Verification         | BF063CAB | BF063CAB        |  |
| Start File               | BF063000 | BF063638        |  |
| Finish File              | BF063637 | BF063697        |  |
| Post-Verification        | BF063CAA | BF063CAA        |  |
| Depth Return Error (in.) | N/A      | 0.0             |  |
| Comments                 | None     | Repeat section. |  |

### **Logging Operation Notes:**

Zero reference was the ground surface, and the borehole was logged through drill pipe. Logging was performed with a centralizer installed on the sonde.

SGLS data were collected using Gamma 2E. Pre- and post-survey verification measurements employed the Amersham KUT (<sup>40</sup>K, <sup>238</sup>U, and <sup>232</sup>Th) verifier with serial number 082.

HRLS data were collected using Gamma 1C. Pre- and post-survey verification measurements employed the <sup>137</sup>Cs verifier with serial number 1013.

#### **Analysis Notes:**

| Analyst | Sobczyk | Date:  | 7/2/03     | Reference: | GJO-HGLP 1.6.3. Rev. 0 |
|---------|---------|--------|------------|------------|------------------------|
| 7       | 0000-   | - 4.0. | . , _ , 00 |            | 000 11021 11010, 11011 |

SGLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits. All of the verification spectra were within the control limits except for spectra BE036CAA and BE037CAA. The peak counts per second (cps) at the 2615-keV photopeak was below the control limit in spectrum BE036CAA. The peak counts per second at the 1461-keV photopeak was below the control limit in spectrum BE037CAA. The peak counts per second at the 609-keV, 1461-keV, and 2615- keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for each day were between 2 percent higher and 5 percent lower at the end of the day. Examinations of spectra indicate that the detector functioned normally during all of the logging runs, and the spectra are accepted.

HRLS pre-run and post-run verification spectra were collected at the beginning and end of each day. The spectra were within the acceptance criteria for the field verification of the Gamma 1C logging system (HRLS).

NMLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits established on 12/05/2002. All of the verification spectra were within the control limits.

SGLS and HRLS log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source files: G2EMar03.xls and G1CApr03.xls), using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. The casing configuration was assumed to be one string of 10-in. casing to 111 ft, one string of 8-in. casing to 149 ft, and one string of 6-in. casing to 303 ft. Below 303 ft, open hole was logged to a depth of 305 ft. The casing correction factor was calculated using casing thicknesses of 15/32 in., 1/2 in., and 9/16 in. for the 10-in., 8-in., and 6-in. casings, respectively. Because the borehole was logged in stages, the casing correction is not additive; the borehole was logged through one string of casing during each logging run. A water correction was not needed or applied to the data.

Using the SGLS, dead time greater than 40 percent was encountered in the intervals from 32 to 69 ft, 73 to 78 ft, and 80 to 86 ft. Data from these regions were considered unreliable. At SGLS dead time greater than 40 percent, peak spreading and pulse pile-up effects may result in underestimation of activities. This effect is not entirely corrected by the dead time correction, and the extent of error increases with increasing dead time. SGLS dead time corrections were applied when dead time surpassed 10.5 percent. The HRLS was utilized to obtain data where the SGLS dead time exceeded 40 percent.

NMLS log spectra were processed in batch mode using APTEC SUPERVISOR to determine count rates. Zero reference was the ground surface. The volume fraction of water was calculated (for the portion of the borehole with 6 in. and 8 in. casing) in EXCEL, using parameters determined from analysis of recent calibration data. Calibration data are not available for the 10-in. casing.

#### **Log Plot Notes:**

Separate log plots are provided for gross gamma and dead time, gross gamma and neutron total counts, gross gamma and volume fraction of water, naturally occurring radionuclides ( $^{40}$ K,  $^{238}$ U, and  $^{232}$ Th), and man-made radionuclides. The neutron-moisture data are displayed in a counts per second format on the combination plot so the data can be compared over the entire length of the borehole. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The  $^{214}$ Bi peak at 1764 keV was used to determine the naturally occurring  $^{238}$ U concentrations on the combination plot rather than the  $^{214}$ Bi peak at 609 keV because it exhibited slightly higher net counts per second.

#### **Results and Interpretations:**

<sup>137</sup>Cs, <sup>238</sup>U, and <sup>154</sup>Eu were the man-made radionuclides detected in this borehole. <sup>137</sup>Cs was detected near the ground surface (0 through 7 ft) at concentrations ranging from 0.3 to 14 pCi/g. <sup>137</sup>Cs was detected in the interval from 30 through 111 ft at concentrations ranging from 0.6 to 121,000 pCi/g. The maximum concentration of <sup>137</sup>Cs was measured at 35 ft. <sup>137</sup>Cs was also detected at 25 ft, 119 ft, 120 ft, and 268 ft with concentrations of 0.3, 0.3, 0.9, and 0.2 pCi/g, respectively. Processed <sup>238</sup>U was detected at 118 ft with a concentration of 13 pCi/g. <sup>154</sup>Eu was detected at 31 ft with a concentration of approximately 9 pCi/g. It is likely that <sup>154</sup>Eu also occurs within the high rate zone from 32 to 69 ft.

Recognizable changes in the KUT logs occurred in this borehole. At 23 ft, there is a 4-pCi/g decrease in <sup>40</sup>K concentration and a 0.3-pCi/g decrease in <sup>232</sup>Th concentration. Between 109 and 112 ft, there is an apparent 10-pCi/g increase in <sup>40</sup>K concentration. Between 146 and 150 ft, there is an apparent 15-pCi/g increase in <sup>40</sup>K concentration and a 1.0-pCi/g increase in <sup>238</sup>U concentration. These increases are associated with the different geometry near the base of the borehole as it was logged in stages. Below 185 ft, there is a 4-pCi/g decrease in <sup>40</sup>K concentration, which represents a transition to coarser grained sediments.

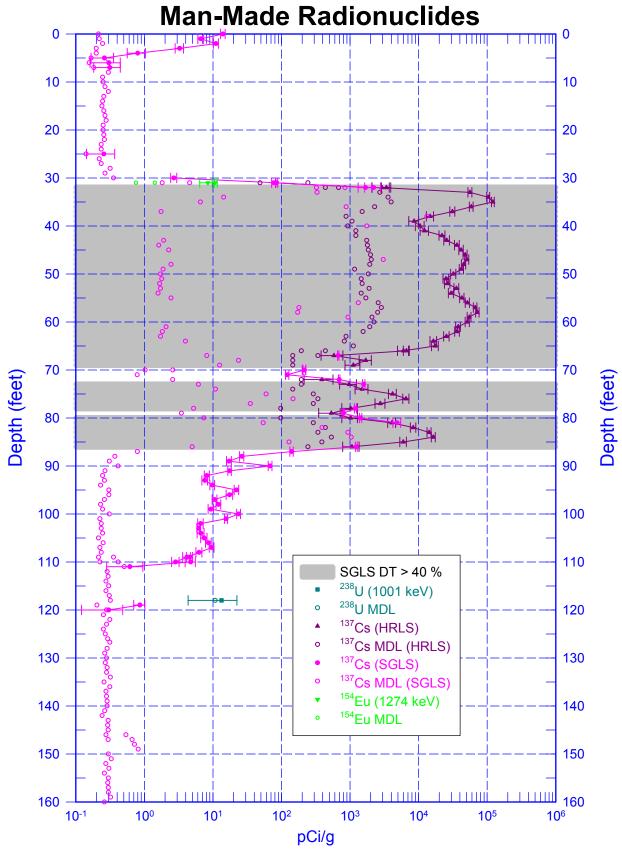
The plots of the repeat logs demonstrate reasonable repeatability of the HRLS, SGLS, and NMLS data. The man-made and natural radionuclides at energy levels of 662, 609, 1461, 1764, and 2614 keV are comparable between the repeat and original SGLS log runs. The <sup>137</sup>Cs detected at 25 and 111 ft did not repeat. The man-made radionuclide at the energy level of 662 keV (<sup>137</sup>Cs) is comparable between the repeat and original HRLS log runs.

<sup>&</sup>lt;sup>1</sup> GWL – groundwater level

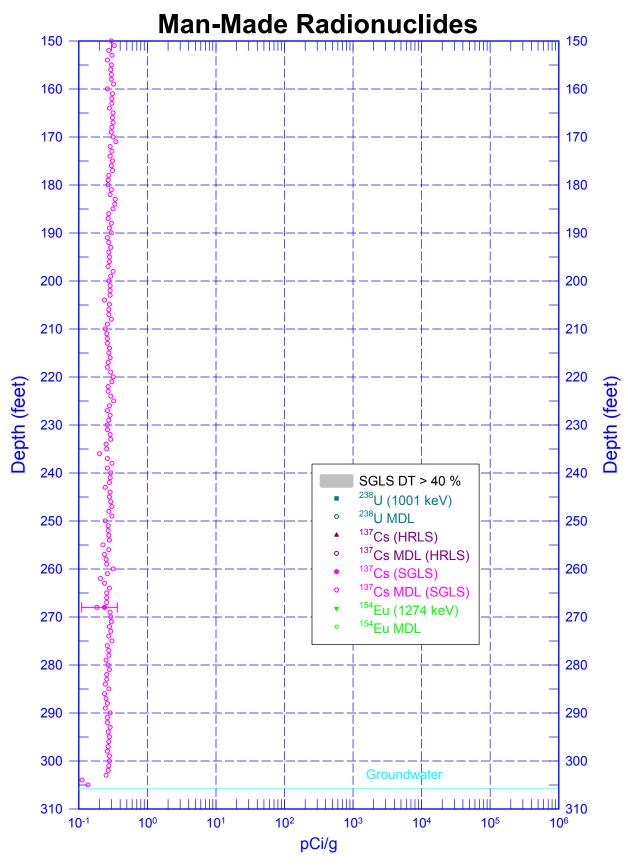
<sup>&</sup>lt;sup>2</sup> TOC – top of casing

<sup>&</sup>lt;sup>3</sup> N/A – not applicable

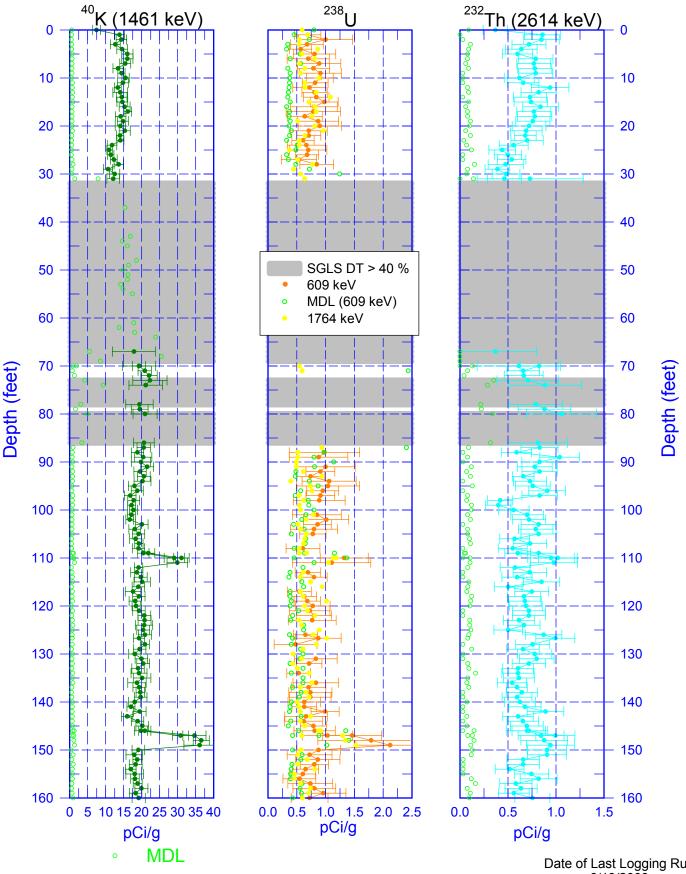
C3246



C3246



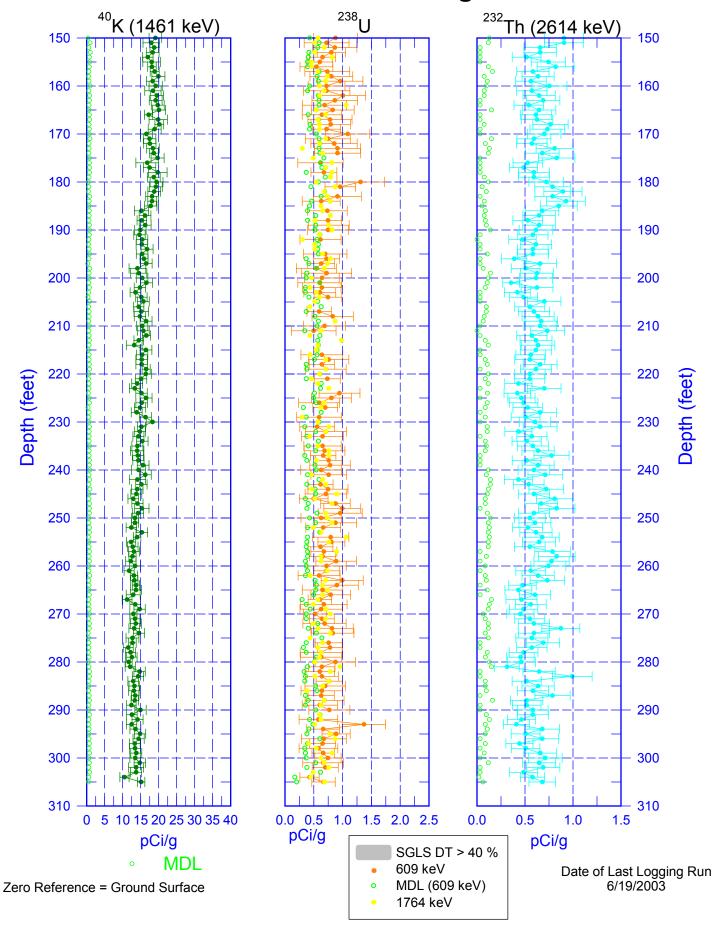
C3246 **Natural Gamma Logs** 



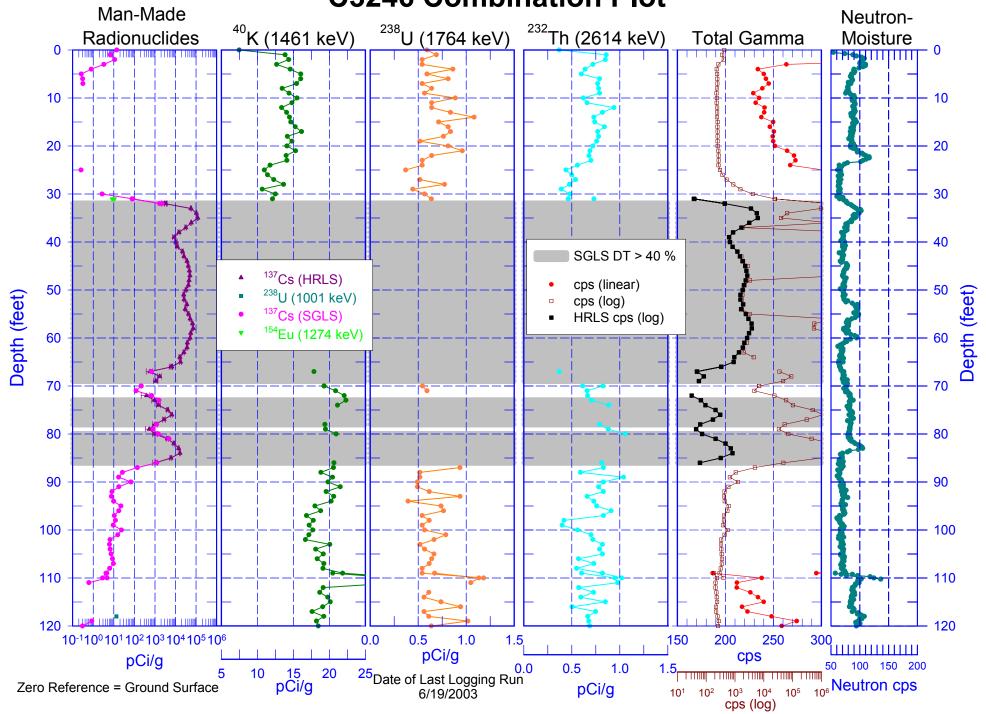
Zero Reference = Ground Surface

Date of Last Logging Run 6/19/2003

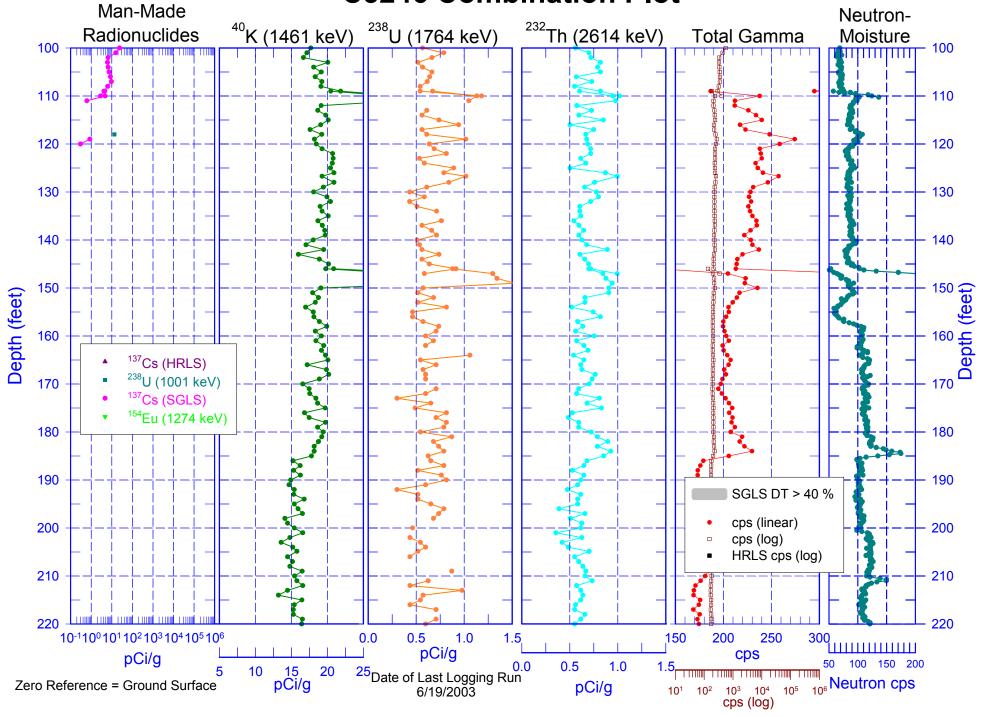
C3246 Natural Gamma Logs



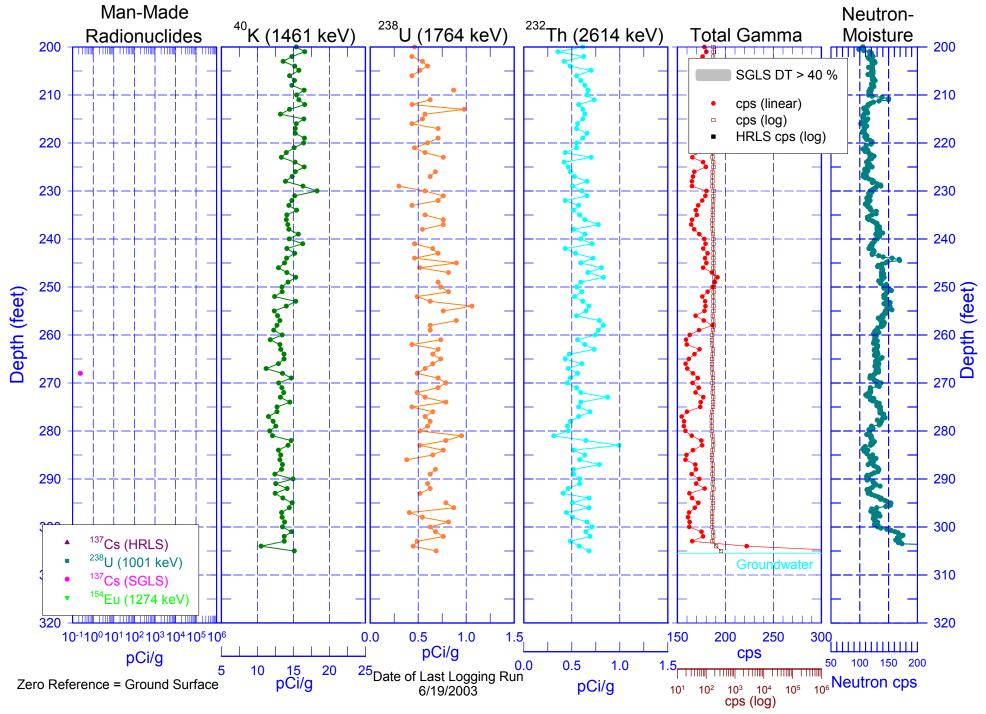
# **C3246 Combination Plot**



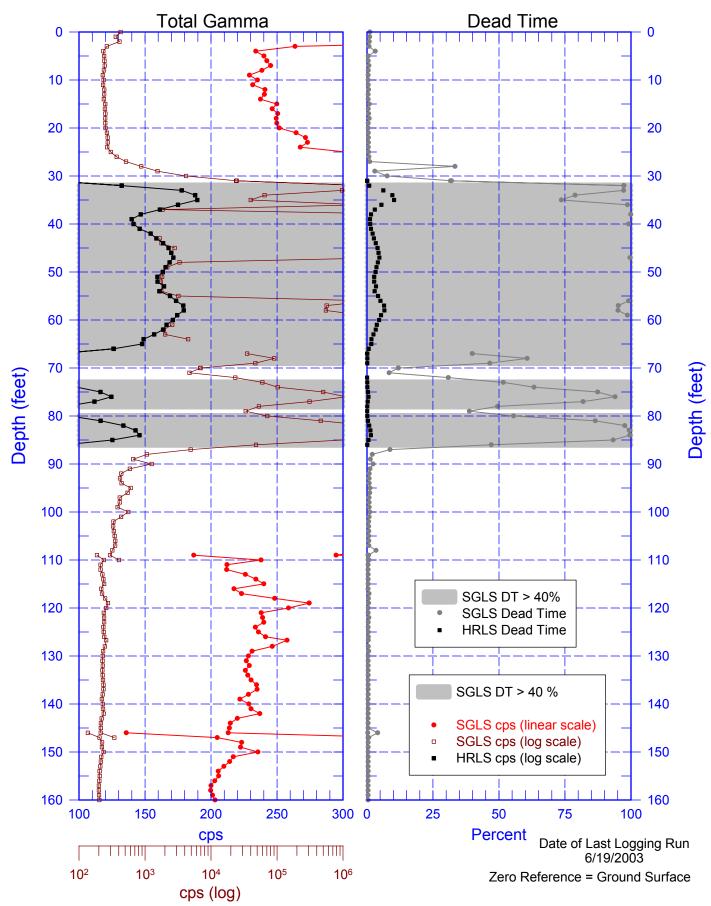
# **C3246 Combination Plot**



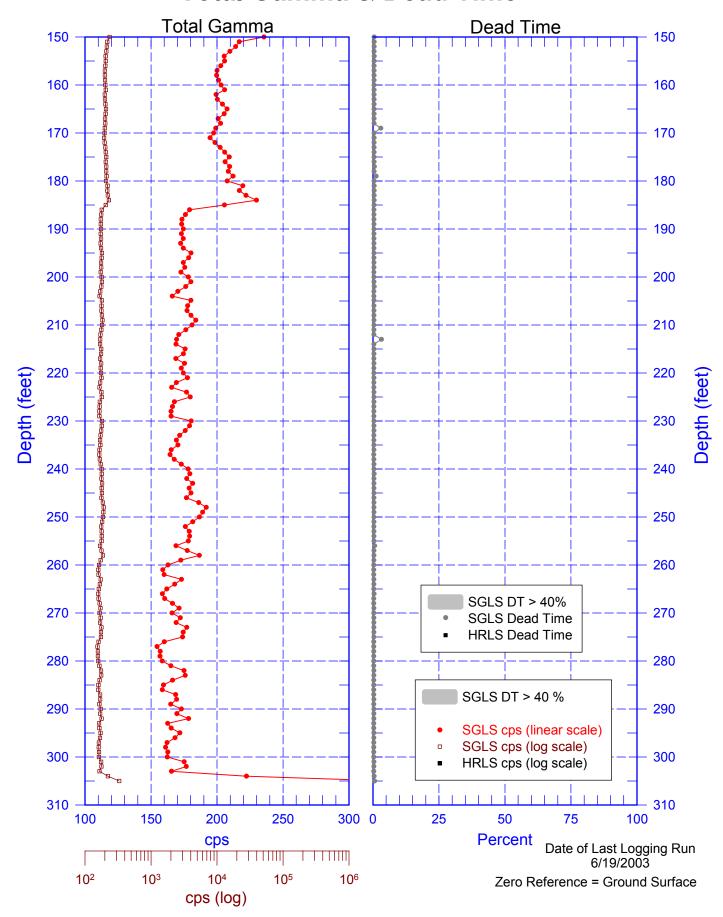
# **C3246 Combination Plot**



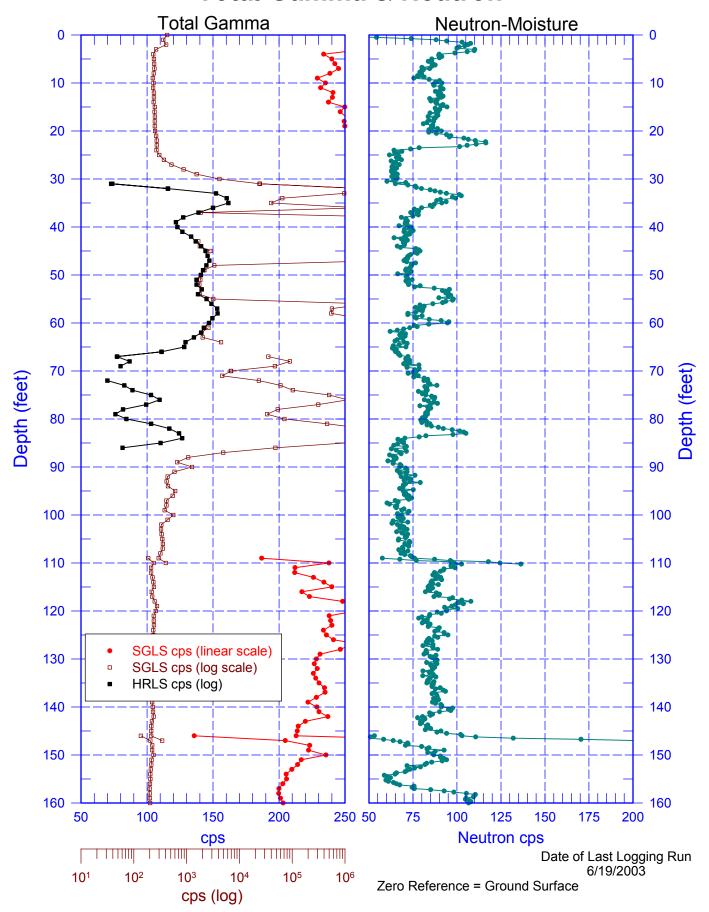
C3246
Total Gamma & Dead Time



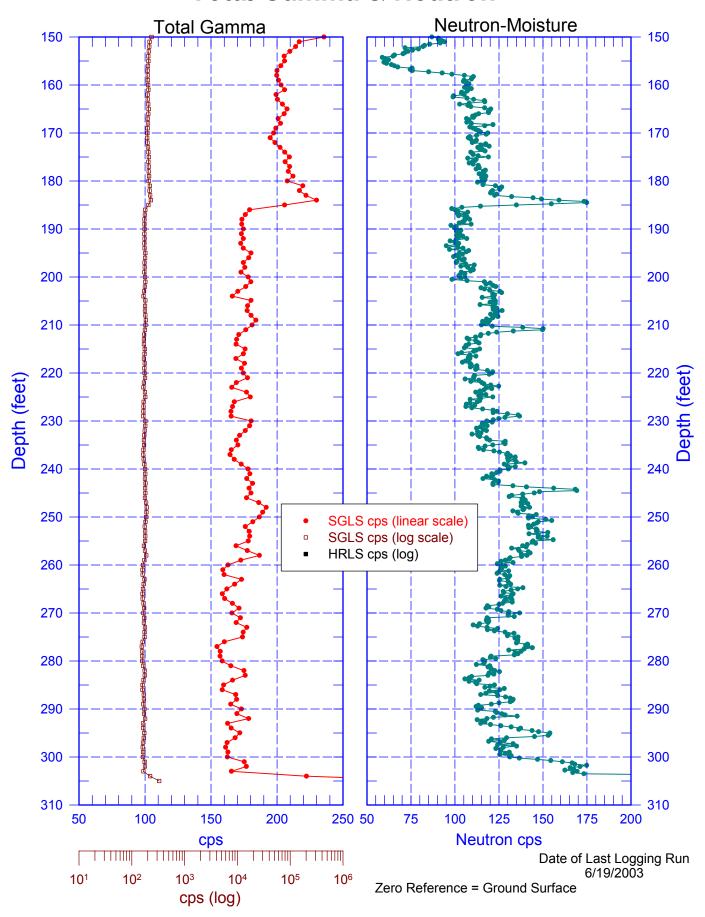
C3246
Total Gamma & Dead Time



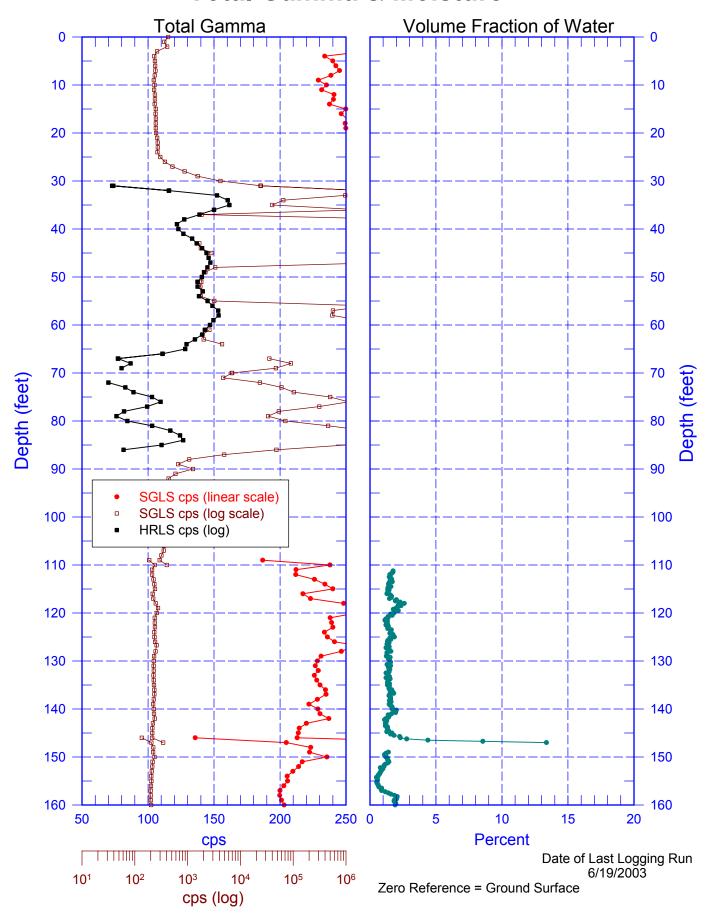
C3246
Total Gamma & Neutron



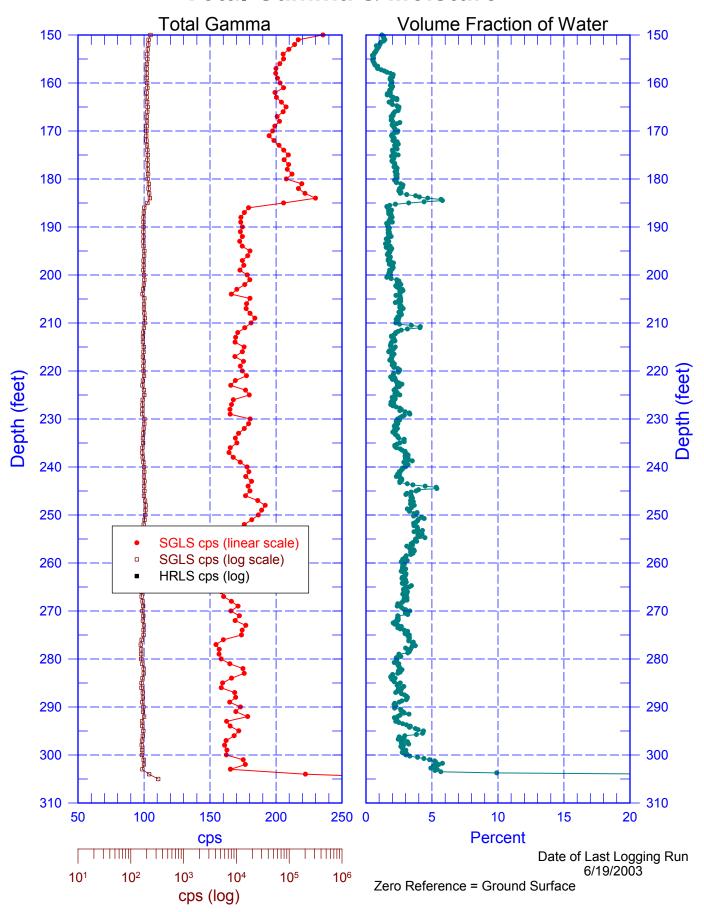
C3246
Total Gamma & Neutron



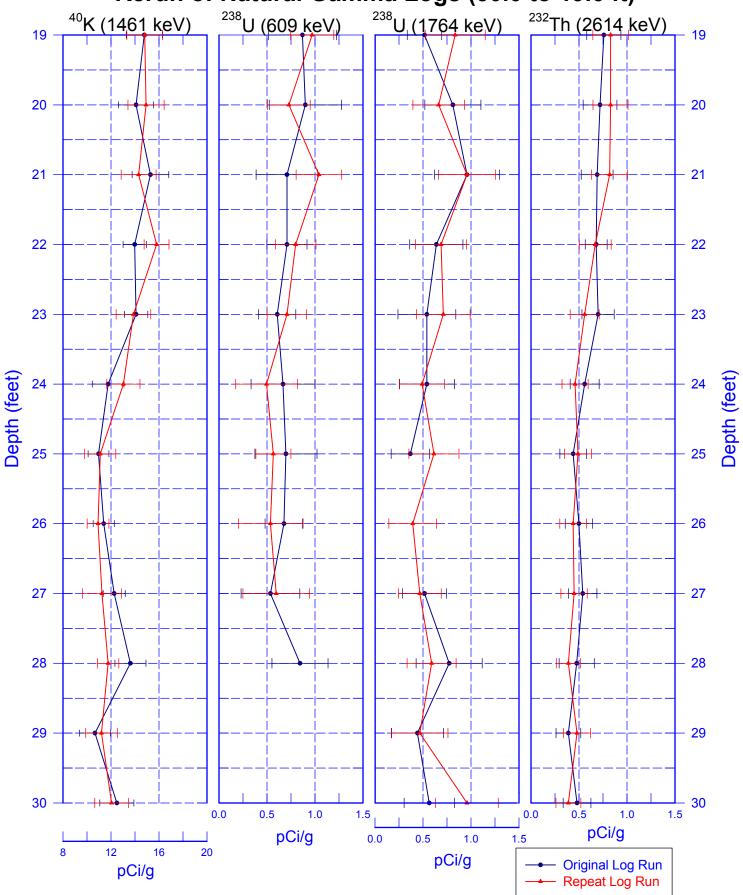
C3246
Total Gamma & Moisture



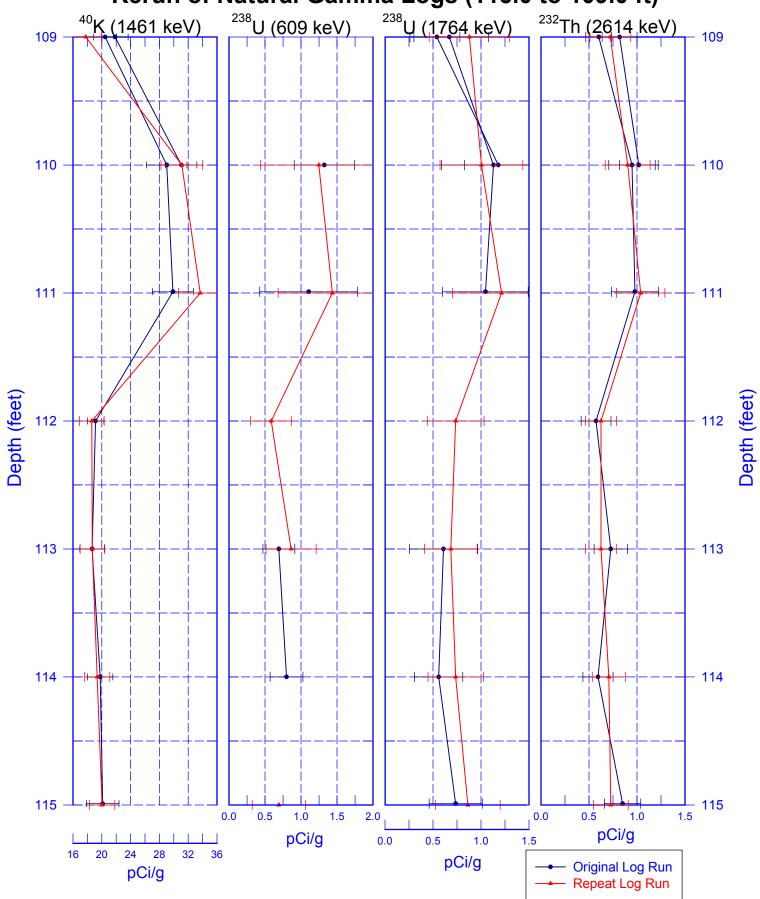
C3246
Total Gamma & Moisture



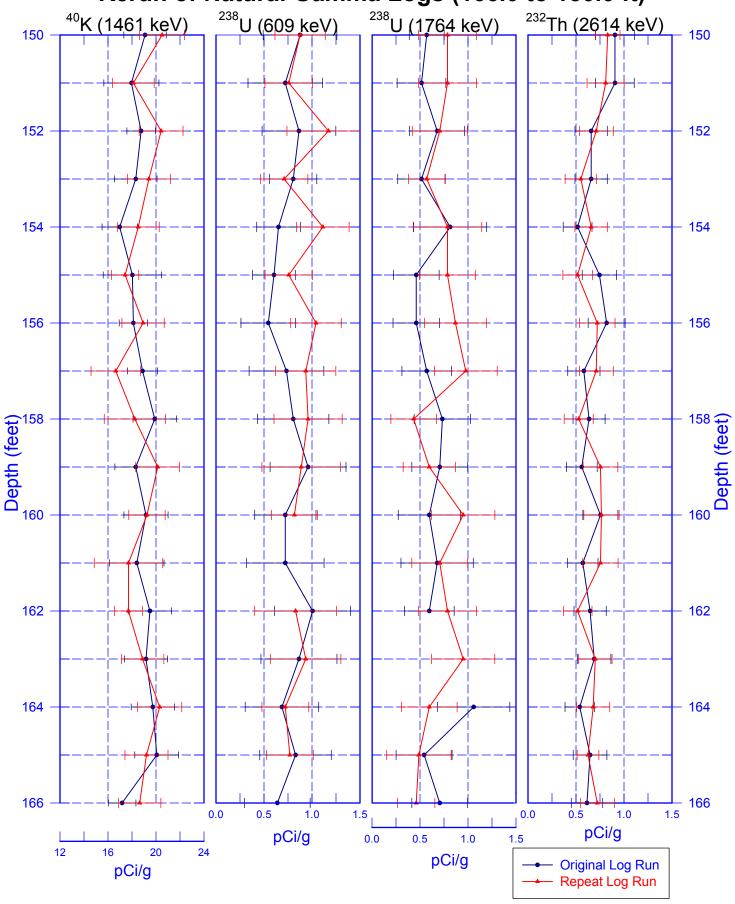
C3246
Rerun of Natural Gamma Logs (30.0 to 19.0 ft)



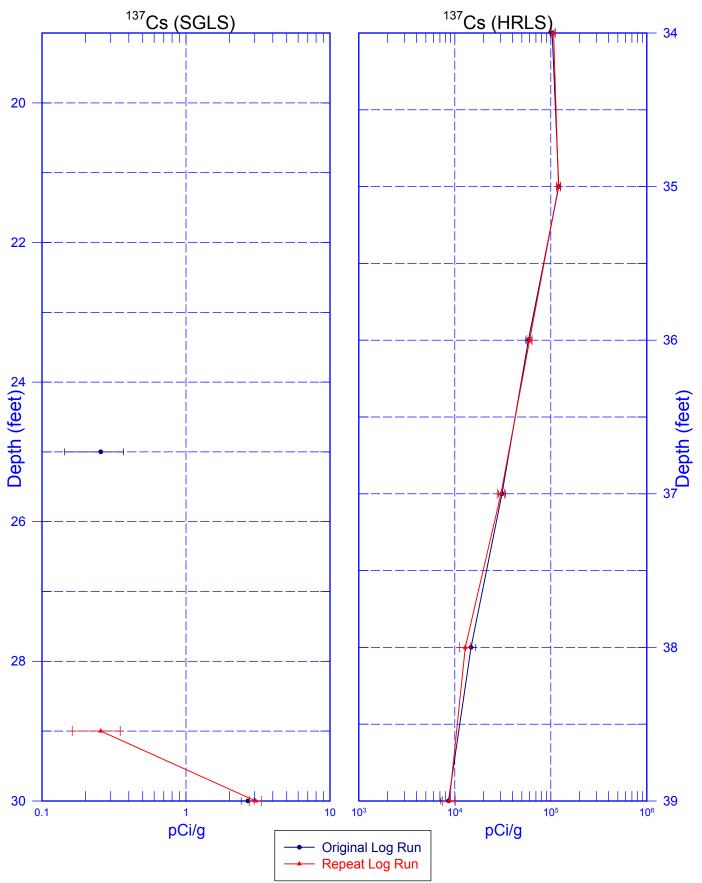
C3246
Rerun of Natural Gamma Logs (115.0 to 109.0 ft)



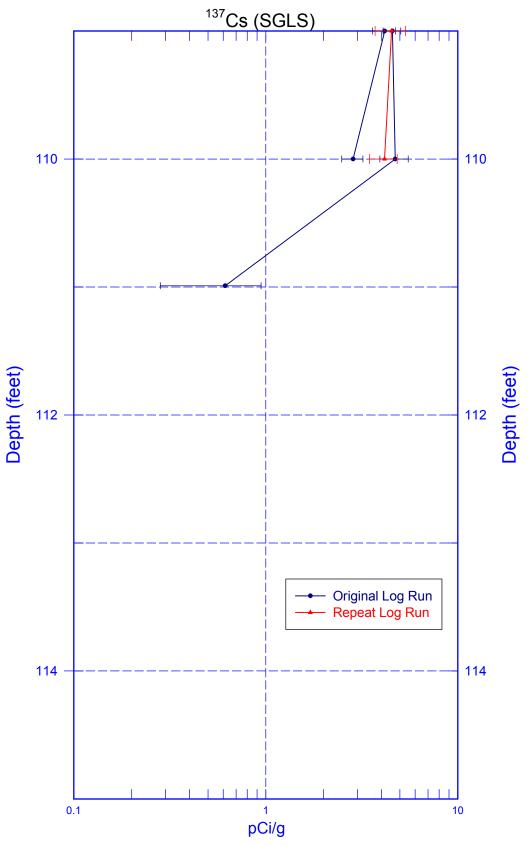
C3246
Rerun of Natural Gamma Logs (166.0 to 150.0 ft)



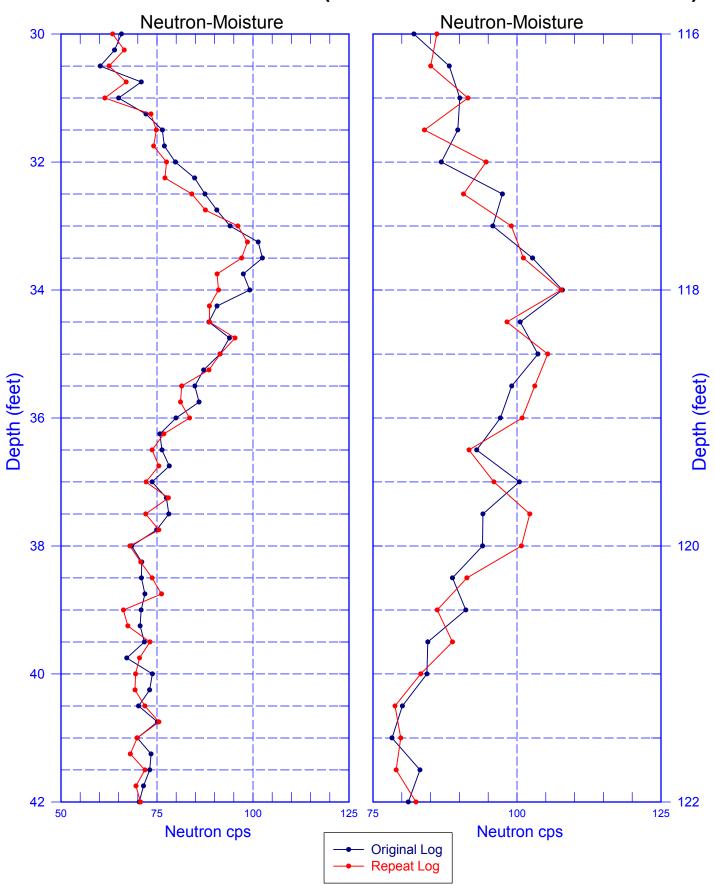
C3246
Rerun of Man-Made Radionuclides



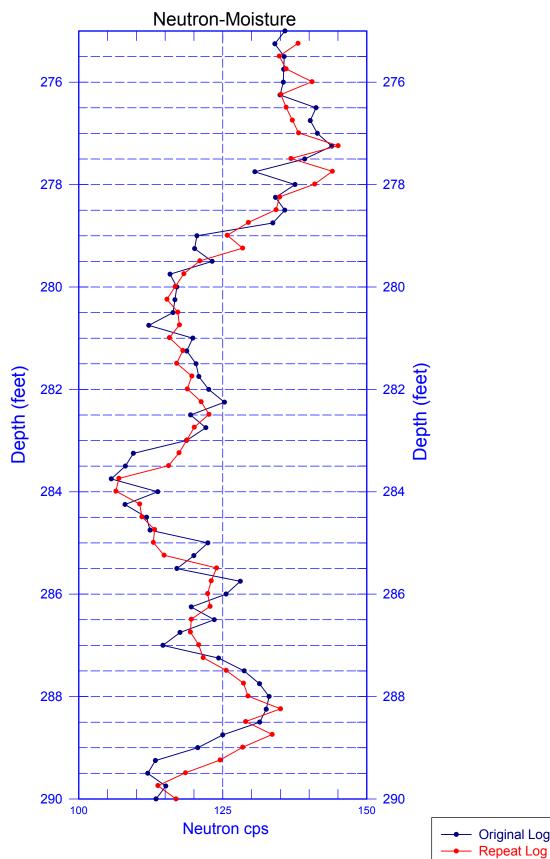
C3246
Rerun of Man-Made Radionuclides



C3246
Rerun of Neutron-Moisture (30.0 to 42.0 ft & 116.0 to 122.0 ft)



C3246 Rerun of Neutron-Moisture (275.0 to 290.0 ft)



Original Log